NOTES ON ANCIENT BRITISH MONUMENTS.

I.

The Aberdeen Circles. A Letter to Dr. Angus Fraser.

DEAR DR. FRASER,

I told you when leaving Aberdeen that so soon as I had discussed the observations of the stone circles I was enabled to make, thanks to your kindness in placing your motor-car at our disposal, you should be the first to know of the results.

Here is my report. Before I refer to the observations themselves I will just say why I was so anxious to have a look at your circles. During the last year my wife and I had photographed and measured several circles in Cornwall and Devonshire. We found outstanding stones, apparently to indicate certain directions in which observations should be made from the centre of each circle. I studied the chief directions astronomically, and found that they might have been used to observe the rising places of stars and of the sun at different times of the year in each circle, and that practically the same places of star and sun rising were observed in all the circles. This indicated a general use: we were dealing with a system, and not with a chapter of accidents. Each circle might have been a town-clock and farmer's almanac combined, whatever other purpose of utility it may have served.

I gave an account of this work in my book "Stonehenge," and very briefly in a letter to *The Times* (July 30, 1906).

Now before I went to Aberdeen, Mr. A. L. Lewis, a great authority on these ancient monuments, had told me that your circles were different from those in south England. In each of your most perfect circles there is, instead of a *standing* stone outside the circle, a *recumbent* stone inserted between two of the stones of which the circle itself is composed. Not only had I got this information from Mr. Lewis, but I had had the advantage of seeing the many plans prepared for the Gunning fellowship reports by Mr. Coles, the assistant keeper of the Museum of Antiquities at Edinburgh.

The question, then, was, might the *recumbent* stones in the Aberdeen circles play the same part as the *outstanding* stones in Cornwall and Devonshire? If so, of course, they could have been used with the same object, that, namely, of indicating a direction; they would only represent a difference of design, not of purpose.

An inspection of some of the available plans suggested that in the recumbent stone and its supporters we had a special form of "cove," the direction required being indicated by a line *across the circle* perpendicular to the length of the recumbent stone.

If this were so, we should find the Aberdeen *recumbent* stones placed *at right angles* to the chief direction lines to the *outstanding* stones found in S. England; lines used for the star- and sun-places I have detailed in my book "Stonehenge," and therefore dealing with practically the same declinations; latitude and heights of hills being taken into account.

Now to settle this point it was necessary to obtain trustworthy azimuths of these directions, and of the angular height of the horizon in each direction, and it is here that I owe so much to the kindness of friends in Aberdeen which I am most anxious to acknowledge. The University authorities, represented by Prof. Macdonald, lent me a theodolite, you placed your motor-car at our disposal, and Dr. Milne was good enough to suggest circles to examine, and accompanied us to the sites.

The circles examined were Sunhoney, Midmar, Auchquhorties (Fetternear), Raes of Clune, and Old Bourtree Bush.

Friday, September 28.—Sunhoney, lat. N. 57° 8′, az. N. 46° E., horizon 4° high. These numbers are only approximations, for the recumbent stone is curved, and the horizon is covered by trees. Midmar, lat. 57° 8′, az. N. 42° E., horizon 1° 30′ high. The alignment was taken on the stone across the circle, its line of direction being, apparently, at right angles to the front surface of the recumbent stone. The height of horizon is doubtful, in consequence of trees.

Saturday, September 29.—Auchquhorties (Fetternear), lat. N. 57° 16′, az. N. 19° E., horizon 2° 30′ high (assumed half-way up the trees).

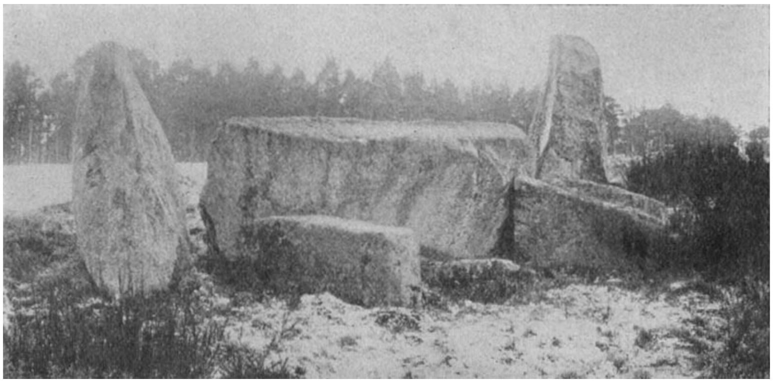

Photo. by Mr. Ritchie.

FIG. 1.—The recumbent stone at Auchquhorties, showing supporters and other stones directed to the centre of the circle.

Monday, October 1.—Raes of Clune, lat. N. 57° 5′. No measures were made, as the ground near the recumbent stone had been excavated, and the stone disturbed. Mr. Braid, who had taken much trouble to enable us to find the site, and whom we met near it, promised to make a new survey of this and the other adjoining circles for examination at some future time. Old Bourtree Bush, lat. N. 57° 3′, az. N. 270° W., horizon not measured.

Before I discuss these measurements in detail, let me say that the first result which stares one in the face is very remarkable.

The measurements of the first five circles, which were selected at random, show that two, like the restored Stonehenge, could watch the sunrise at the summer solstice. The direction line of another resembles those of a dozen circles in S. England, built, as I hold, to watch the rise of the clock-star, and the only other one measured is directed to the sunset at the equinoxes.

To enter into details. I take the magnetic variation for 1906 at 18° 30′ W.; this then has to be applied to the compass bearing to get the *true* azimuth. I also give a table of the solstitial azimuths, taking heights of hills into account, for lat. 57°:—

	True Azimuths	
	Summer	Winter
With sea horizon	N. 41° 0 E.	S. 41° 46 E.
,, 1° elevation	43 40	42 10
,, 2° ,, ...	46 16	39 30
,, 3° ,, ...	48 20	36 46
,, 4° ,, ...	50 24	33 56

These values apply in a general way to both Sunhoney and Midmar. The difference of azimuth observed arises from the fact that there is, roughly, a difference of 2° in the angular height of the horizon at the two places. I attach greater weight to the measures at Midmar, as the direction was taken to a stone on the other side of the circle. It may be that this way of making the direction line "siccer" was generally taken; the plans suggest but do not prove it.

Let us, then, look at the Midmar result a little more closely. My rough measures gave an azimuth of N. 42° E. According to the above table the azimuth of the solstitial sunrise to-day, with hills 1° 30′ high, is practically N. 45° E. There is a difference of 3°.

Now in your latitude at the solstice, the sun when it rises or sets grazes the horizon for a long time; the direction of its apparent motion is only slightly inclined to the horizon. To-day it is about 27°. A change in the sun's declination due to the change in the obliquity of the ecliptic, which was greater in past times, will therefore produce a great change in the azimuth of sunrise. Thus to give figures ready to my hand, if instead of the present declination of 23° 27′ we take 23° 50′, the declination at B.C. 1000, according to Stockwell's calculations, the present azimuth of N. 44° 58′ E. (with hills 1° 30′ high) becomes N. 43° 57′ E.

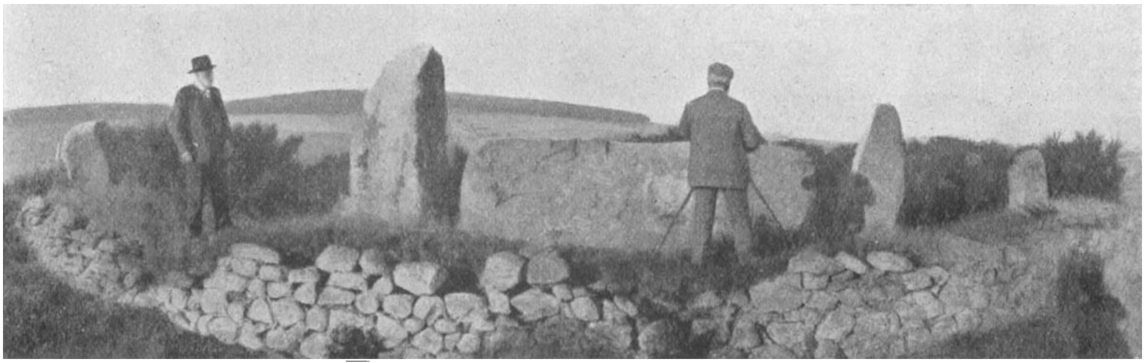

Photo. by Lady Lockyer.

FIG. 2.—The recumbent stone and its supporters at Auchquhorties. View from the back looking across the circle.

Now this is a degree nearer my value of the azimuth; and if that value is not very much out, and if the recumbent stone was arranged in relation to the solstice, it is clear that the Midmar stones were set up more than 3000 years ago.

To carry this inquiry further, observations much more complete than mine, including observations of the sun with accurate time to get the astronomical bearing directly, are required. We want, too, observations in winter when the leaves are off the trees, so that the height of the horizon can be accurately measured.

To such observations *in your high latitude* I attach very great importance, since changes in direction due to the change of obliquity of the ecliptic can be considered under much more favourable conditions than in S. England in the case of circles connected with the sun at a solstice.

I pass to the azimuth N. 19° E. at Auchquhorties. In S. England, as stated in "Stonehenge," the available clock-stars were Arcturus and Capella. But this was for lat. N. 50°. How about lat. N. 57°? I find that for this latitude these two stars were the only ones available for part of the time, and, further, that Castor might have been used at another time.

In the district round Aberdeen, and especially to the westward, the height of the horizon varies greatly. How this affects the star question, and how it is needful for archæologists to take account of it, will be gathered from the accompanying diagram, which Mr. Rolston has been good enough to prepare.

To show the use to be made of it, let us take the observed azimuth at Auchquhorties, N. 19° E. With hills 2° 30′ high, we find that if a star were really in question, it must at the time of circle-building have had a north declination of 33°. This was Capella's declination about B.C. 1640, and Arcturus's about B.C. 600.

There is a difference of a thousand years, and if further inquiries show that either or both of these stars may have been used in connection with these circles, some progress will surely have been made which it seems cannot be made without it.

It will be clear that when *final* observations have been made at Midmar and other circles which may be connected with a solstice, the sun and star dates may be compared, and each may throw light on the other. For instance, if the final values for Midmar come anywhere near my provisional ones, we shall have an argument in favour of Capella as against Arcturus at Auchquhorties, for it is fair to assume that the circles in any one region, whether solar or stellar, were started at *about* the same time; at least, the evidence furnished by the Cornish monuments is in this direction.

The result of such detailed inquiries as these will do much to enable us to form an opinion touching the possibility of astronomical considerations having been taken into account by the builders of the monuments.

I wish to plead for the examination of these circles in the widest possible sense. As I have said, they may have served several purposes, some of them at present undreamt of, and in this connection I protest against the logic of those who hold that because graves have been found in them they were constructed wholly for purposes of burial, and that no other considerations were in the minds of those who set up the stones. It is the same thing as to say that because graves are found in our churches, the churches themselves were not built for the worship of God.

While I am writing to you I see in the *Scotsman* (November 8) that recent explorations at Fernworthy Circle, on Dartmoor, have shown that every inch of its area is covered with wood charcoal. "In fact, fires seem to have been kindled all over the circle, for every scoop of the pick and shovel which was removed from the floor displayed charcoal." Now this looks much more like the result of a succession of Beltaine, or other fires, year after year than of burials; and there would be the closest connection between the orientation of the circle which showed when the time of festival had arrived and the fire which proclaimed its advent.

But any way, the more uses were made of the circles the better they are worth investigating.

I have no doubt that connected with your magnificent University (and I do not forget that I am now one of you) there is, or soon will be, a strong School of Archæology, happier than most such schools in that you have a fine field of exploration at your doors, for there are 175 stone circles in your shire alone, shown in the Ordnance maps.

Now let me keep to my own parish and try to point out that a research touching the application of the orientation theory to these circles would certainly be a source of the greatest interest to the researcher.

First he would have to arrange his observations so that he could discuss the value or the futility of the theory taken as a whole; and then if the theory proved valid he would have to hunt down the use of the May, solstitial or equinoctial year and the stars used as clock-stars. The thing bristles with plots for detective stories.

What a time the alumnus of this School who has best studied the methods of Sherlock Holmes will have!

First of all, of course, he must visit the ground, that is, the circles, and among the large number he need consider, in the first instance, only those that have well-marked recumbent stones. On this point he should consult Mr. Ritchie, of Port Elphinstone, who has, I believe, photographed them all (and let me say here how grateful I am to him for the gift of several mounted prints, one of which, with his permission, I have copied above). Next, let him neglect the names, weights, and colours of the riders—I mean the stones—and simply determine the azimuth of the line at right angles to the recumbent stone taken across the circle, and the height of the horizon in that direction. Even the university theodolite is not absolutely necessary; an azimuth compass, and a "clinometer" which can go in the waistcoat pocket, will suffice for a reconnaissance.

Now for "clues."

Are the azimuths all helter-skelter, that is, distributed anyhow, among the four quarters of the circle from 0° to 359°? (If so, the culprits need not be sought among astronomers, and the orientation theory is all moonshine.)

Is an azimuth, say between N. 10° and 25° E., pretty common or quite exceptional? (If pretty common, this will strengthen the view that we are dealing with observations of a clock-star and that blind chance has nothing to do with the inquiry.)

Is there any relation between the azimuths and the amount of squaring of the stones? (If so, as the non-squared stones are most probably the oldest, if the azimuths decrease as the squaring gets more pronounced we are dealing with Capella; see diagram.)

Is there another group of azimuths between N. 40° and 48° E.? (If so, as this is the solstitial alignment, it will strengthen the astronomical view.)

Are there any azimuths about N. 58° E.? The rising place of the sun at the beginning of May at the Beltaine feast? (If not, we have an argument against great age, as the oldest sun alignments in Cornwall and along the west coast deal with the May-year.)

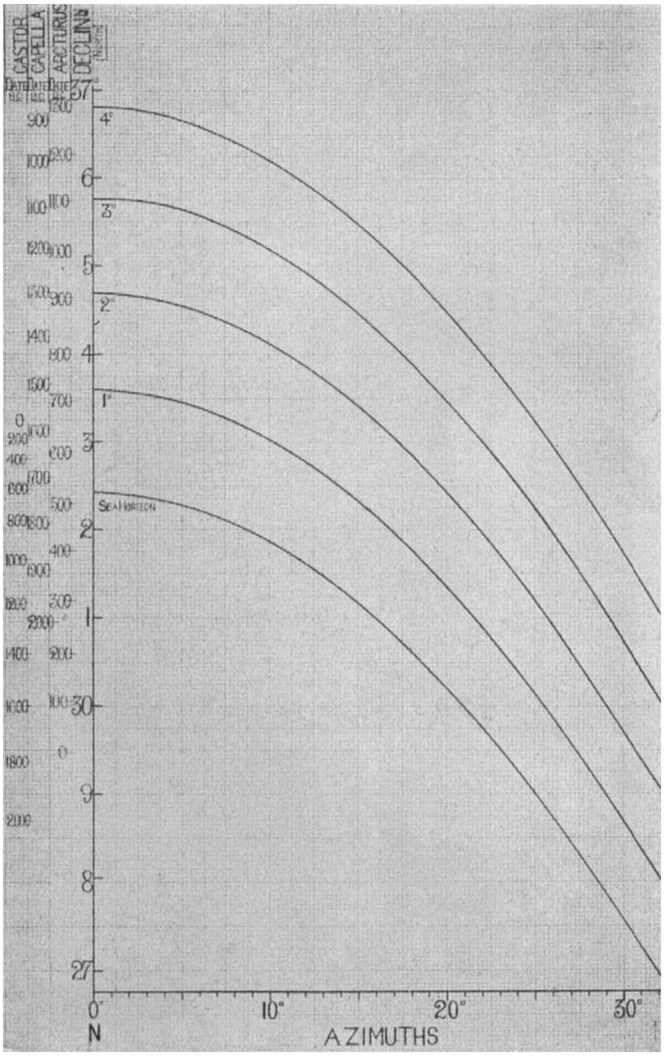

FIG. 3.—Showing the dates at which the stars Arcturus, Capella and Castor rose at the azimuths indicated, the heights of the horizon being taken into account.

Is the Aberdeen form found anywhere else? (If so, the other regions in Europe or elsewhere to which it is common may be regarded as in some way connected with the form.)

Is it a general rule that the heights of the stones decrease from the recumbent stone to the opposite side of the circle? (If so, the relation of this to the naos at Stonehenge must be considered.)

I hope I have succeeded in showing you that there are many points of great interest connected with your Aberdeen stone monuments which are well worth investigation.

I hope, also, that Aberdonians will see that the necessary work is done. How I wish I could be with you to help in it, and renew the pleasures you allowed my wife and myself to feel, going about among the relics of a long bygone past in your most modern motor car.

Always sincerely yours,
NORMAN LOCKYER.

APPLICATIONS OF THE MICROPHONE PRINCIPLE.

AN interesting booklet upon applications of the microphone principle has been written by Messrs. Jensen and Sieveking, of the physical laboratories in Hamburg and Karlsruhe.[1] By the term "microphone principle" the authors mean all those phenomena which are due to the change of ohmic resistance between loose contacts. The memoir contains a very exhaustive collection of what is to be found scattered in scientific literature from the time of Munck of Rosenschoeld, to the present day. The explanation that in loose contacts the nearer approach of the particles resulting from the application of pressure is the cause of the diminished resistance observed, is ascribed to du Moncel and Beetz, who gave it almost simultaneously, though independently. Among the early practical applications of this property of loose contacts was Hughes's induction balance, which is so well known that no lengthy reference need be given here. A less known though also interesting application may, however, be mentioned, namely, the demonstration of nodes and antinodes in acoustic waves in cylindrical vessels. By lowering a small microphone into the cylinder, Fossati succeeded in locating the position of the nodes and antinodes by means of a telephone receiver connected with the microphone. The sound waves impinging against the loose contacts produce a rasping sound in the telephone, which vanishes when the microphone reaches the position of a node. In a darkened room minute sparks may be seen between the microphone plates when the microphone is in the position of an antinode.

Another acoustic application of the microphone made quite recently by Hebb is the determination of the velocity of sound. He uses two parabolic mirrors facing each other, and placed on the same axis. The one is fixed, and the other can be moved to a greater or lesser distance. In the focus of the first or fixed mirror is placed a tuning fork and a microphone, in the focus of the movable mirror a second microphone. The secondary of an induction coil having two primary windings is connected to a telephone. The primary windings are connected each with a battery and one of the microphones. The sound waves of the tuning fork act directly on the microphone next to it, and the reflected sound waves on the microphone in the movable mirror. It is easy to see that the loudness of the tone given out by the telephone depends on the frequency of the tuning fork, the distance between the two mirrors, and the velocity of sound. If both microphones receive antinodes at the same time, the tone is loudest, and if there is a phase difference of half a period between them the tone is weakest. Now the phase difference depends on the distance between the mirrors, the length of the acoustic wave, and the frequency. By first carefully determining the latter, and then finding the position of strongest and weakest sound, Hebb was able to determine with great accuracy the velocity of sound. He found it to be 331.29 metres, the probable mean error being only 0.04 m.

The attempts to use the microphone in seismography do not seem to have led to any practical or trustworthy result. Rossi, in 1887, used a microphone consisting of a silver plate and pointed lever in his underground observatory near Rome, and noticed that the telephone gave out sounds which were unmistakably the effect of seismic movements, and when afterwards the apparatus was tranferred to Vesuvius and came under Palmieri's observation, a general agreement between the sounds in the telephone and the records of the seismograph was observed, but the difficulty of separating sounds due to other causes seems to have stood in the way of further developments. Nevertheless, the authors think that the microphone may be made a seismographic instrument of great sensitiveness.

An ingenious application of the microphone for the detection of fire-damp has been made in France by Hardy. If the sound waves of two pipes of equal pitch impinge on microphones connected in series with a telephone a clear note is heard, but if one of the pipes emits a but slightly different note there will be beats heard in the telephone. Now if one pipe is on the bank and the other underground, the latter, if there be fire-damp, will be blown with air of a different density and emit a different note. The telephone, by sounding beats, will then give warning of the presence of fire-damp. The apparatus when tested with coal gas showed great sensitiveness. An admixture of but 0.1 per cent. gave three beats in twenty seconds, and an admixture of 1 per cent. gave thirty beats in twenty seconds.

The memoir deals very fully with the use of the microphone in telephony, including the production of graphic records such as are given by the instruments of Nernst, Lieben, Poulsen, and others. Also the use of the microphone in wireless telephony is touched upon. The most directly useful part of the memoir is, however, a very full account of the work done by a large number of experimenters in order to ascertain the best composition of the material forming the loose contact of the microphone, its mass, area of contact, specific pressure, and other determining factors as regards strength and clearness of sound.

The connection between the microphone and wireless telegraphy is not obvious, and the authors deal with this part of their subject very briefly. One sentence is, however, so interesting that it may, in conclusion of this short review, be quoted verbatim. The authors say:—"Already in 1879 Hughes has used the influence of spark discharges on microphonic resistances for wireless telegraphy over a distance of 400 meters."

GISBERT KAPP.

SIR EDWARD J. REED, K.C.B., F.R.S.

THE death of Sir Edward James Reed on November 30 brought a long, useful, and highly distinguished career to a close. He was in his seventy-seventh year—full of activity, with mind as vigorous, and interests in life and work as keen, as ever. He was an active worker to the end. For the greater part of the last half-century he was the most prominent naval architect of his time. His influence during that long and important period in the progress of naval construction was one of the most potent forces that shaped its development and improvement. That influence was exerted, not only by his work and teaching, but also by constant and earnest efforts from his earliest days to promote the scientific education and training of young men

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[1] Anwendungen des Mikrophonprinzips." By Chr. Jensen and H. Sieveking. (Hamburg: Graefe and Sille.)